Applied Magnetic Resonance
https://doi.org/10.1007/s00723-018-1044-8

Applied
Magnetic Resonance

ORIGINAL PAPER

Verification of Diffusion MRI Fiber Tracking Results In Vivo

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Received: 12 May 2018 / Revised: 4 July 2018

Abstract
Fiber tracking based on diffusion-weighted magnetic resonance imaging data has become an important tool for studying the human brain structure in vivo, but fiber tracking results need verification. The proposed approach makes it possible to verify fiber tracking results using two parameters—the diffusion probability along the fiber segment direction and Shannon entropy. It was demonstrated that the proposed method helps to find invalid connections on simulated phantoms, then the method was applied to fiber tracking results for in vivo single-shell and multishell data. It was found that the proposed method enabled the improvement of the quality of in vivo fiber tracking results.

1 Introduction

Diffusion-weighted magnetic resonance imaging (DW-MRI) has become a very important tool for studying human brain. Fiber tracking (FT) algorithms, which use local information about self-diffusion of water, attempt to characterize the connectivity between different regions of human brain at the macroscopic level. Deterministic algorithms [1–3], probabilistic algorithms [4–6] and global algorithms [7–11] attempt to solve the inverse problem—to reconstruct the trajectories of fibers from the measured data. The limited resolution of DW-MRI images (the voxel size is much larger than the axon diameter), noise and artifacts in data lead to the errors in results. Accordingly, the FT results should be verified. Currently, there are several conventional approaches to verifying the FT results: (1) invasive methods such as manganese tracing of postmortem investigation in histological brain sections, which are independent of possible errors in MRI data, diffusion model limitations, imperfections in data post processing and analyses, but they are limited to animal and in vitro studies [12–14]; (2) the development of physical phantoms, the disadvantage of this method is the simplicity of such phantoms in comparison with the structure of the human brain tissue [15, 16]; (3) the validation using simulated data for digital

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Published online: 27 July 2018